APPENDIX F

CONCERNS RAISED ABOUT POPULATION CHANGE CRITERIA APPROACH

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In reviews of a previous draft of this document a number of concerns were raised about the population change criteria (PCC) approach. A summary of some of these concerns and brief responses follow. More detailed discussion of these issues is found in Appendix D.

Concern Raised: PVA models are not predictive enough to set thresholds.

Population viability analysis models (PVAs) attempt to predict low-probability events for long time spans into the future. This can be notoriously imprecise. Fieberg and Ellner (2000) suggest that it is possible to predict into the future only 1/10 the length of the time series of available data. Reed et al. (2002) recommend against the use of PVAs to set minimum population sizes. We agree completely that PVA models, such as the one we use, should be interpreted with extreme caution, particularly with regard to minimum sizes. However, these models tend to be most sensitive to error when the intrinsic productivity is near the threshold of 1. If a population clearly has an intrinsic productivity less than 1, the models robustly predict that a population will go extinct. Conversely, if the intrinsic productivity is clearly greater than 1, the models robustly predict that a population will persist. The conclusion is robust in the sense that it is not overly sensitive to estimates of variability or to the actual abundance of the population. If a productivity estimate is near 0, the extinction prediction is highly sensitive to the variance and abundance estimate. (These points are illustrated in Fieberg and Ellner 2000, Figure 1.) The PCC approach focuses on estimating the population's productivity and demonstrating that it is greater than 1. This takes advantage of the situation in which PVA models provide the most predictive power.

Concern Raised: Approach is nontraditional and ignores common fisheries modeling to estimate productivity.

The basic question addressed by traditional fisheries modeling is different than the question addressed in setting viability criteria. Traditional fisheries models are designed to address the question, "How much of this healthy population can be harvested?" The question posed by delisting criteria is, "What is the best way to determine when a threatened population is no longer in danger of extinction?" Although different in some key respects than traditional fisheries models, the PCC approach shares many features. Like traditional fisheries modeling, it considers intrinsic productivity, density dependence, and variation to predict future population performance. The main difference is in the method used to estimate productivity. The PCC approach is not expected to provide a measure of the intrinsic productivity, but rather to provide a statistically defensible bound on the productivity. Reviewers of this approach have suggested that fitting recruitment curves to recruits per spawner data is the way to determine the "true" intrinsic productivity. As demonstrated in Appendix D, recruits per spawner data often provide little information on the true intrinsic productivity, and alternative methods are needed. In those exceptional cases in which recruits per spawner data are informative, we recommend evaluating population status using those data.

Concern Raised:
Approach sets different abundance levels for different populations, not a fixed number.

The extinction risk to a population depends on both a population's productivity and its abundance. A fixed minimum abundance threshold for all populations would only be appropriate if all populations had the same productivity. One approach to setting a fixed minimum size might be to assume that all populations had a productivity of 1. The minimum sizes suggested by this assumption tend to be quite large, and this is also the range over which PVA models are most uncertain. An alternative approach might be to assume (set as a target) a productivity greater than 1. If the productivity is set, for example, at 1.1, under the PVA models evaluated the minimum population size for a low extinction risk drops to a range of a few hundred fish. The critical issue becomes not setting and evaluating a minimum abundance threshold, but evaluating the population's productivity. The PCC approach evaluates productivity by measuring population growth. The population growth rate is estimated based on the difference between the current abundance and a target future abundance; different populations will have different targets because they have different current abundances. The PCC approach actually does not use a fixed productivity threshold; rather, it simultaneously examines population abundance and productivity. As a consequence, populations that are currently small must show a greater proportional increase in abundance than populations that are currently large.

Concern Raised:
Approach requires all populations to increase from current abundance, even those that are relatively large and stable.
(Or, "What about the Lewis River brights?")

The population change approach relies on observed growth rate as an estimate of intrinsic productivity. The approach is most appropriate when applied to populations that have been depressed below historical abundance. If a population is relatively large and apparently stable, an intuitive conclusion is that the population has a low risk of extinction. However, the intuitive perception depends explicitly or implicitly on an assumption that the population has some resilience (i.e., intrinsic productivity > 1), because even quite large populations can have a substantial risk of extinction if they have no resilience. The challenge once again is to demonstrate that a population has an acceptable intrinsic productivity. Different null hypotheses regarding the growth rate may be appropriate depending on the situation. For example, if we observe a pristine population fluctuating around historical abundance, we would not need to observe the population grow to conclude that it is sufficiently resilient to persist. The assumption of historical condition would be enough evidence to reach that conclusion. However, if we observe a population depressed to a small fraction of its historical abundance, we may require substantial statistical evidence before concluding that a population has an adequate intrinsic productivity. In limited cases, the statistical evidence may be provided by fitting recruitment curves to observed recruits per spawner data. In these cases, adequate resilience may be concluded without observing an actual population increase. However, in the majority of cases, recruits per spawner data are uninformative regarding intrinsic productivity, and the PCC are a useful method of providing the needed statistical rigor. It is important to note with regard to the Lewis River bright chinook salmon population that the target for a category 3 population is actually lower than the average abundance over the last 20 years, which suggests that the criteria are not unattainable, even for this relatively large population.

Concern Raised: The model is sensitive to the begin and end dates for the growth rate estimates.

The median annual growth rate is conceptually based on a formula that includes data from every year:

$$\hat{\lambda} = \exp\left(mean \left(\ln\left(\frac{N_{t+1}}{N_t} \right) \right) \right).$$

However, this equation simplifies to

$$\hat{\lambda} = \exp\left(\frac{1}{y} \ln\left(\frac{N_{t\arg et}}{N_{inital}} \right) \right),$$

where y is the number of years between the initial abundance and target abundance counts. Thus, estimating the median annual growth rate is a function of the initial and target population sizes and is sensitive to the dates selected for these periods. Three features of the PCC as they have been developed help reduce the sensitivity to the selected start period date. First is the use of a four-year average for the abundance estimates, which tends to smooth out much of the interannual variation. The second feature is requiring a relatively long observation period, which increases the likelihood of picking up the true underlying growth rate. The third feature is the marine survival rate correction, which attempts to correct for the marine regime shifts. It is important to note that the PCC are intended to provide initial targets, and that we expect biologists in the future, when evolutionarily significant units (ESUs) are actually being contemplated for delisting, to perform quantitative risk analysis with the tools available at that time and to explore the consequences of the time frames evaluated.

Concern Raised:
Model is too sensitive to QET.

Population viability models tend to be sensitive to the quasi-extinction threshold (QET) value. The QET value is the abundance below which the population should not drop, either because of increased extinction risk or uncertainty. Setting the QET value is difficult and somewhat arbitrary (e.g., there is no real scientific way to distinguish between the appropriateness of a QET of 50 spawners or 60 spawners.) The PCC approach is moderately sensitive to QET. Because it depends on estimates of intrinsic productivity greater than 1, the results are much less sensitive than minimum size estimates, assuming that intrinsic productivity equals 1. For details on the reasons for this conclusion, see Appendix D.

Concern Raised:
Stationarity assumption about variance.

In setting targets in this report, we assume that the environmental variance observed for the recent past is predictive of the environmental variance we will observe in the future. We recognize that this parameter may change in response to management actions, and we encourage the constant reassessment of this parameter. However, we note that detecting changes in environmental variance is extremely challenging and requires long time series of abundance.

Concern Raised:
Population change criteria need to be met once.

This concern actually raises several issues, one of which is regarding the stationarity assumption. The stationarity assumption is that a population's behavior over the observation period will continue into the future. This is a basic assumption, and one that confronts any effort to predict the future based on data collected during an observation period. For example, if intrinsic productivity were estimated by fitting a recruitment curve to recruits per spawner data, the intrinsic productivity estimate would constitute a criterion that is met once. In order to reach a conclusion about a population's risk status, a stationarity assumption needs to be applied. A second part of this concern involves issues about annual variability and the possibility of meeting the criteria by chance. The approach used to set the target abundances explicitly considers annual variability, and the extinction risk associated with the target considers the uncertainty surrounding the population growth rate estimate. The sensitivity to single-year variation is addressed partially by evaluating four-year averages, not single years.

Confusion Expressed:
When is the status of the population evaluated?

The target growth rates in Table 4.2 of the main text are for a 20-year observation period. To evaluate the status of a population relative to these criteria, it would be necessary to compare the size of the population in 20 years to the target size. The population would not automatically be considered viable *even if it exceeded the target abundance at some point prior to the end of the 20 years.* This is because the PCC consider the length of the observation period as an import parameter in estimating the target. Target abundances can be easily calculated for shorter or longer observation periods, but the targets will likely differ from those in Table 4.2 if the observation period is other than 20 years (targets for different observation periods are provided in Appendix D). The relationship between target size and observation period involves tradeoffs between two factors. If the same abundance is reached in a shorter time, it implies a higher growth rate and a decreased probability that the population will go extinct. However, a shorter observation period leads to increased uncertainty, which tends to increase our estimate of the probability that the population may go extinct. The exact balance between these opposing tendencies can only be determined by doing the calculation. Theoretically, a target abundance could be calculated for every year into the future and compared to the observed abundance. This approach has some merit; however, a minimum number of observation periods are required to obtain any precision with growth rate estimates. Work by Holmes (2002) suggests that a minimum of 12 to 15 years of data are needed, assuming there are no long-period (decadal-scale) cycles or regime shifts in marine survival. Given that there are long-period cycles or regime shifts in marine survival, the observation period should be as long as possible to average over as much of the range of marine survivals as possible. For this reason, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) suggests an observation period of about 20 years. The target abundances based on a 20-year observation period shown in Table 4.2 are intended as general guideposts for population risk criteria. If the criteria were set as a target over 20 years, it would NOT be necessary to wait 20 years to evaluate whether the population is headed in the right direction. It would be possible to estimate the likelihood that a population is on track to make the goal from a shorter time series. Such an estimate would be imprecise (too imprecise to conclude viability), but would indicate whether the population is improving or declining.

Concern Raised:
The targets cannot be completely predetermined.

The targets should be viewed as initial estimates of the target abundances, not as the final answer carved in stone. On a general note, there will undoubtedly be advances (or at least modifications) in risk assessment methods over the next several decades, and we expect criteria to be regularly reevaluated and modified. Considering the approach we have developed, the criteria cannot be completely specified in advance because the abundance target, which is conditional on several key parameters, must be examined retrospectively to determine risk. To evaluate a population's viability using the PCC approach requires estimating the fraction of hatchery-origin spawners that effectively spawn in the wild and marine survival during the observation period. Managers could theoretically predict the number of hatchery-origin spawners in the wild because that is in large part under human control. However, the WLC-TRT has not been provided with any projections, so information on this parameter could not be incorporated into the targets. Even if projections were provided, they would be just that—projections; it would be necessary to wait and observe the actual pattern of hatchery spawning. Since the level of hatchery spawning in the wild is expected to change over time, providing targets in advance is especially difficult. The marine survival parameter also cannot be predicted with precision; it must be evaluated retrospectively to determine whether the population has reached sufficient size over the observation period.

Concern Raised:
Model does not provide guidance on actions.

The PCC approach is one tool for evaluating whether a threatened population is still in danger of extinction. It is not intended to provide guidance on what actions should be taken to recover populations. It is intended to evaluate whether the cumulative effect of all actions has accomplished the objective of reducing the risk of extinction.

Concern Raised:
Low abundance default is arbitrary.

Many populations in the WLC domain are extirpated or currently at very low abundance. Because the PCC have an increased uncertainty at very small population sizes, and cannot be calculated at all for an extirpated population, a low-abundance default was applied. The low-abundance default is an assumption about the current population size. The larger the assumed current population size, the higher the target needed to reach a given persistence probability. The selection of the low-abundance default value is based on professional judgment and is informed by an understanding of the processes that contribute to uncertainty at small population sizes. However, there is no quantitative justification of the value selected. In practice, it may be advisable to wait and develop a population change target after the population has increased in abundance sufficiently to obtain a relatively precise estimate of the population size.

Concern Raised:
Targets are not established for all populations.

Developing PCC targets requires an estimate of the current spawner abundance. For some populations in the WLC domain, adequate data were not available to estimate current population abundance. Before targets can be developed for these populations it is necessary to obtain an estimate of the four-year average abundance. It is not appropriate to apply the low-abundance default to these populations because if the actual abundance is greater than the default, the population change targets would be underestimated.

Concern Raised:
Single variance estimate for all populations.

Every population is unique and likely has its own pattern of response to environmental variation. However, estimates of variation from individual populations are very uncertain, and a better estimate can often be obtained by averaging the estimates from multiple populations. As variance estimates are refined by the collection of more data over time, it is hoped that population—or at least ESU-specific estimates—can be developed.

Concern Raised:
The approach is too complex.

The PCC are not as easy to explain as a simple abundance threshold. However, the basic concepts underlying them are relatively simple. A viable population must be resilient. A reasonable way (but not the only way) to estimate resilience is by observing a population's growth rate, which is measured by a change in abundance over time. The PCC work out in advance how much change is required over a given time to conclude the population has a low probability of extinction. Although understanding the mathematics and statistics underlying the calculations may require specialized expertise, explaining the basic results and consequences of the criteria to watershed planners should not. The basic message is that populations need to increase in abundance, and Appendix D gives some ballpark indication of how much and how fast. It is true that the criteria are not as easy to explain as a simple abundance threshold. However, the criteria address the key issue of productivity in addition to abundance, and the slight additional complexity is worth the extra effort in explanation. Any criteria approach that requires measuring productivity is going to be inherently more complex than a simple abundance threshold. For example, the alternative recruits-per-spawner approach might be familiar to fisheries biologists, but it is not a trivial thing to explain to a broader audience.

Literature Cited

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